Status of HGA anomaly investigations on 2003-06-13

1. The anomaly started with the on-board HGA (High Gain Antenna) monitoring triggering a communications backup on May 4. It turned out that 2 encoder pulses were missing since May 1. The antenna is driven by 2 motors: one for the azimuth (Z-axis) and one for the elevation (Y-axis). The anomaly is on the Z-axis.
   The encoder is a disk with 2 holes mounted on the motor shaft giving 2 pulses per revolution. Between the motor and the antenna there is a harmonic drive with a reduction factor of 160. One revolution of the motor shaft corresponds to 1.5 ° movement of the antenna. Each motor revolution needs 240 steps, so we expect one encoder pulse every 120 steps.

2. After missing 2 pulses on the Z axis the encoder pulses returned for a short while (two pulses were seen), but they were 7 steps too early relative to the regular 120 steps interval. Then we missed an other pulse (the third one). The pulses came back again, this time exactly in phase with the original 120 steps interval between pulses.

3. There were two possible failure scenarios: either the motor had been stepping properly and the antenna had moved, but the telemetry was wrong, or the telemetry was right and we had actually been missing steps, i.e. the antenna was falling behind.

4. On May 25 we were at the extreme of the halo orbit, meaning that the antenna Z-axis had to start moving in the opposite direction from May 25 onward. In order not to lose evidence we decided to stop the antenna movements on May 25.

5. A test was designed to measure the position of the earth in the antenna pattern by moving the spacecraft to +2° and -2° in yaw (corresponding to +2°and -2° extra in antenna azimuth) and moving the antenna Y axis in small steps while measuring the ground and on-board received signal strength. This test was performed on June 4. Beforehand we had calculated the expected results based on the two possible failure scenarios given above.
   We had expected that the antenna pattern would be symmetric w.r.t. the antenna Y-axis. The test result showed it was not. There seems to be a systematic offset in both Z- and Y-axes. Correcting for this offset, the test result was very close to the “antenna missing steps, TM OK” case.
   Note however that we do not have a measurement of the in-flight antenna pattern. During the spacecraft commissioning this test was skipped, based on the excellent performance of the RF subsystem so far. Looking further into the antenna pattern measurements done by Ericsson in 1993 it seems that the pattern could be offset from the mechanical center by one to several degrees. This puts the conclusion of the June 4 test in doubt.

6. On June 12 we resumed the nominal antenna pointing after a nominal station keeping and momentum management maneuver on June 11. We had to catch up for the measured offsets in the June 4 test. The antenna had to be moved 120 steps in Y and 234 steps in Z. The Y-axis movement performed as expected. On the Z-axis we got the first encoder pulse exactly where we expected it (accounting for the hysteresis due to the reversal of direction). However the second pulse, which was expected during this movement, did not arrive. During the following 2 regular movements we should have gotten the next encoder pulse on the Z-axis, but this one never occurred.

7. Based on the above, we know it is an intermittent problem. Due to the uncertainty about the antenna pattern we still cannot say categorically if it is a telemetry or a motor/mechanical problem. Therefore we plan to do a second off-pointing test next week (Wednesday June 18 or Thursday June 19), which should give us a second position of the earth in the antenna pattern. Together with the June 4 results we should be able to tell if the antenna moved properly or not.

8. So far, due to the current position of the spacecraft on its halo orbit combined with the ± 3dB beam width of the antenna there has been no noticeable impact on the communication link. Nominal scientific return was maintained.

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